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Application of the 10 Keys Checklist and Partial Extraction Techniques to Optimize Esthetic Outcomes for Adjacent Implants in the Esthetic Zone

Placing immediate implants in the esthetic zone poses significant challenges. Implants should be placed with consideration to hard and soft tissue management to optimize long-term implant and cosmetic success. In this case report, two maxillary central incisors were extracted at two different time points, 5 years apart, due to horizontal root fractures. Implants were placed according to immediate single-tooth guidelines using two different surgical and loading approaches, as risk assessment factors changed in the time between the first implant placement (right central incisor) and second implant placement (left central incisor). These techniques included partial extraction therapy (PET); the use of allograft and growth factors, connective tissue graft, and platelet-rich fibrin; and immediate and conventional loading. These comprise the 10 Keys, a checklist used to pursue long-term success. At the 6-year and 1-year follow-ups, radiographic and clinical results were satisfactory.
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Marginal bone loss (MBL) is a fundamental success criterion in implant dentistry.[1] More recently, great importance was given to gingival health and form.[2,3] Treatment of the esthetic zones is a complex endeavor, as the restoration of anterior teeth demands the gingival form, color, contour, symmetry, papilla height, and texture[4] to match those of the neighboring teeth, and it is therefore described as a complex SAC (straightforward, advanced, complex) procedure.[5,6]

Clinicians should consider strategies that promote long-term tissue stability when placing immediate implants in this area. Levine et al published the 10 Keys checklist, aiming to obtain natural-looking restorations, prevent MBL, and maintain gingival profiles.[7,8]

▲ **Fig 1** *(a)* Pretreatment clinical view showing very large triangular-shaped clinical crowns, very long tapered papilla between the central incisors, and a minor labial recession on the right central incisor. *(b)* Pretreatment radiograph showing complete horizontal root fracture of the right central incisor, approximately at the alveolar crest.

First, a consultation on the patient's esthetic risk assessment (ERA) is paramount.[9] ERA contributes to a correct diagnosis and selection of the optimal surgical approach. A discussion with the patient is needed to communicate realistic expectations and possible limitations.

Another important aspect is the management of the gap between the implant and the buccal bone[10]; slowly resorbing biomaterials used with a planned gap (> 2 mm) will help maintain the buccal bone thickness.[11,12] The buccal wall can almost always be expected to shrink following tooth extraction, requiring surgical compensation, especially in the thin-wall phenotype (< 1 mm thick).[13]

Immediate contour management with a screw-retained provisional restoration can provide better tissue support to the remodeling gingiva, maintaining the zenith and cross-sectional contours. The provisional is shaped to prevent any pressure on the developing interface. A screw-retained final restoration or custom abutment for a cement-retained restoration can eliminate complications from excess cement retention and minimize gingival recession.[14,15]

Dental extractions almost always result in 3D ridge alterations. Partial extraction therapy (PET) has been shown to conserve hard and soft tissue contours by preserving the periodontal complex.[16–19]

This report aims to show the decision process in managing anterior tooth loss in a very challenging patient using a combination of these treatment options.

Materials and Methods

Case Presentation

A healthy, nonsmoking 48-year-old woman was referred for evaluation and treatment of a horizontally fractured maxillary right central incisor (tooth 11; FDI numbering system) (Fig 1). The patient had high esthetic demands and wanted a treatment that had the highest likelihood of replacing the shape of her damaged tooth while preserving tissue contours and without requiring any restoration of the adjacent teeth.

The 10 Keys protocol **[Au: Please briefly summarize the 10 Keys protocol, which was explained in the Abstract and should be mentioned here.]** was followed by first obtaining a CBCT scan and analyzing local conditions. Factors that contributed to high risk are explained in Table 1. After the consultation, it was decided that the best treatment was immediate implant placement with immediate provisionalization, including bone and gingival augmentation. Reporting of this case followed the CARE guidelines.

Table 1 Esthetic Risk Assessment for Treatment of Tooth 11

Esthetic risk factors	Low	Medium	High
Medical status	Healthy, uneventful healing	–	Compromised healing
Smoking habit	Nonsmoker	Light smoker (< 10 cig/day)	Heavy smoker (> 10 cig/day)
Gingival display at full smile	Low	Medium	High
Width of edentulous span	1 tooth (≥ 7 mm)[1] 1 tooth (≥ 6 mm)[2]	1 tooth (< 7 mm)[1] 1 tooth (< 6 mm)[2]	≥ 2 teeth
Shape of tooth crowns	Rectangular	–	Triangular
Restorative status of neighboring teeth	Virgin	–	Restored
Gingival phenotype	Low-scalloped, thick	Medium-scalloped, medium-thick	High-scalloped, thin
Infection at implant site	None	Chronic	Acute
Soft tissue anatomy	Soft tissue intact	–	Soft tissue defects
Bone level at adjacent teeth	≤ 5 mm to contact point	5.5–6.5 mm to contact point	≥ 7 mm to contact point
Facial bone wall*	> 1 mm thick	–	< 1 mm thick
Bone anatomy of alveolar crest	No bone deficiency	Horizontal bone deficiency	Vertical bone deficiency
Patient's esthetic expectations	Realistic expectations	–	Unrealistic expectations

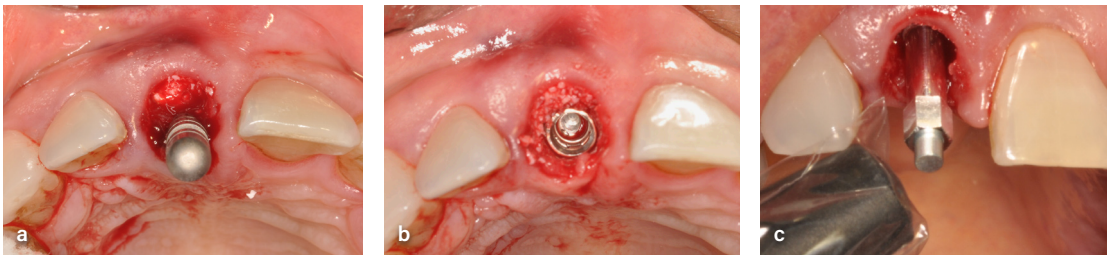
Shaded cells indicate the patient's condition at the evaluation. In addition to the high esthetic risk factors listed here, the patient also had a minor preexisting recession on the soft tissue.
[Au: Please clarify what the asterisk and superscript numbers indicate.]

▲ **Fig 2** The tooth root was sectioned into pieces to facilitate minimally traumatic extraction.

Surgery and Restoration of the Right Central Incisor

One hour before the surgical procedure, the patient was orally premedicated with 2 g amoxicillin and 2 mg lorazepam. Local anesthesia was obtained with articaine with epinephrine 1:200,000. The loose segment of the tooth (tooth 11) was detached using a periotome and saved. The root was divided lengthwise with a fissure bur and extracted in pieces, avoiding damage to the buccal plate (Fig 2).

An osteotomy was created palatal to the apex, anticipating a screw-retained restoration. Position and depth were verified with a guide pin (1.8-mm diameter). During drilling at 800 rpm, sterile saline solution was suctioned with an in-line bone trap (Osseous Coagulum Trap, Salvin Dental Specialties) to capture bone chips.



▲ **Fig 3** *(a)* Final position of the 3.5-mm–diameter guidepin in place with the buccal gap packed with graft material. Note that the buccal gap is similar in diameter to the guidepin. *(b)* Final position of the 4.1-mm–diameter implant with the buccal gap grafted. *(c)* Confirmation of adequate primary stability using a resonance frequency device.

▲ **Fig 4** The provisional restoration finished extraorally with correct contours to promote gingival healing.

▲ **Fig 5** A connective tissue graft was inserted palatally into the prepared site using a resorbable apical suture to both guide the graft into position and secure it apically.

The suction filter contents were transferred to a sterile dappen and hydrated with sterile saline. A 1:3 ratio of autologous bone and anorganic bovine bone (Bio-Oss, Geistlich) were mixed. A 3.5-mm guide pin was placed in the osteotomy, and the graft was gently condensed into the buccal gap (Fig 3a). The pin was removed, and an implant (4.1 x 12 mm; BLT RC, Straumann) was seated 3 mm apical to the gingival margin (Fig 3b). Implant stability was confirmed (ISQ 80/79) using a resonance frequency device (Osstell) (Fig 3c).

The tooth crown was then hollowed, etched, and luted to a titanium temporary cylinder and converted into a screw-retained provisional. The tooth shape, shade, and characterization were preserved. The provisional was then finished in the dental laboratory and polished (Fig 4).

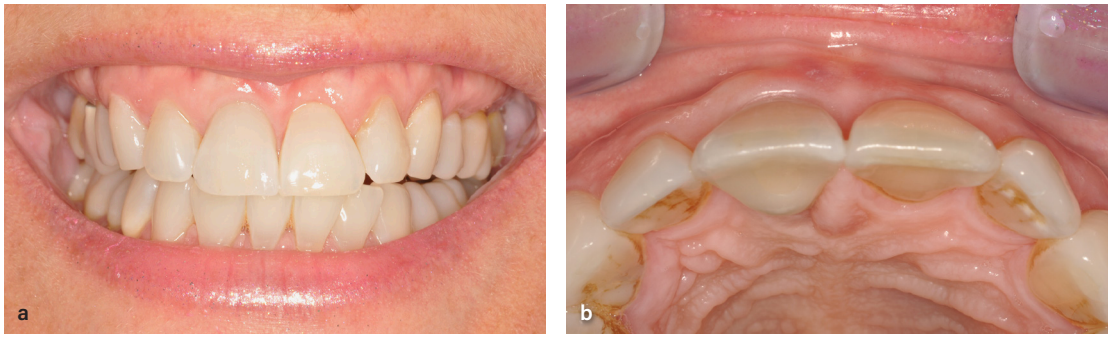
A subepithelial connective tissue graft was harvested from the right palate (5 × 7 × 1.5 mm). The donor site was sutured with 4-0 chromic gut sutures. A labial intrasulcular incision was directed apically, under the gingiva, creating a pouch to place the graft; the graft was secured with a suture (Fig 5). The provisional was placed onto the implant and hand tightened. The access hole was sealed with PTFE and composite. Occlusion was adjusted to confirm no contact in centric or protrusive movements. A radiograph was taken to confirm seating (Fig 6).

The patient returned for uneventful postoperative care and observation at 10 days, 6 weeks, and 3 months. At 3 months, new photographs and radiographs were taken. The gingival margin of the right central incisor healed at a level slightly coronal to the adjacent natural tooth. No

▲ **Fig 6** *(a)* Immediate postoperative view showing how the original tooth was converted to a screw-retained provisional with coronal positioning of the labial tissue to over-correct the pretreatment recession. *(b)* Immediate postoperative radiograph.

▲ **Fig 7** The final restoration was placed on the implant prior to the gingivectomy. Note that the long interdental papilla between the central incisors has been maintained.

▲ **Fig 8** A laser gingivectomy was performed to create an equal gingival margin height and clinical crown length of the central incisors.



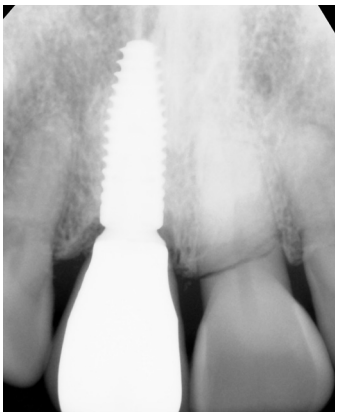
▲ **Fig 9** *(a)* After healing from the laser gingivectomy, the patient's full smile shows significant gingival display, excellent symmetry of central incisors, and maintenance of gingival contours. *(b)* Occlusal view of anterior teeth showing slight over-correction of the root eminence on the implant compared to left central incisor.

dimensional change of the interdental papilla was observed (Fig 7).

The patient was referred to her restorative dentist for refining by adding composite resin on the provisional, but the facial gingiva was too fibrotic to contour with restorative pressure. The dentist was advised to finish the restoration with current contours and then to send the patient back for laser gingival contouring (Fig 8). After healing, the patient was pleased with the esthetics and had difficulty distinguishing between her natural tooth and restoration. Preexisting recession was also corrected (Fig 9a). Occlusally, the root eminence of the tooth was slightly increased compared to the left central incisor (Fig 9b).

After 5 years, the patient was recalled to assess the stability of the results, and she reported that she was very pleased. Tissue levels, color, papilla height, and volume appeared stable (Fig 10).

▲ **Fig 10** Clinical view at 5 years showing maintenance of gingival contours and the long interdental papilla.



▲ **Fig 11** A radiograph taken at the 5-year follow-up shows a root fracture of the left central incisor at the level of the alveolar crest.

Table 2 Esthetic Risk Assessment for Treatment of Tooth 21

Esthetic risk factors	Low	Medium	High
Medical status	Healthy, uneventful healing	–	Compromised healing
Smoking habit	Nonsmoker	Light smoker (< 10 cig/day)	Heavy smoker (> 10 cig/day)
Gingival display at full smile	Low	Medium	High
Width of edentulous span	1 tooth (≥ 7 mm)[1] 1 tooth (≥ 6 mm)[2]	1 tooth (< 7 mm)[1] 1 tooth (< 6 mm)[2]	≥ 2 teeth
Shape of tooth crowns	Rectangular	–	Triangular
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Gingival phenotype	Low-scalloped, thick	Medium-scalloped, medium-thick	High-scalloped, thin
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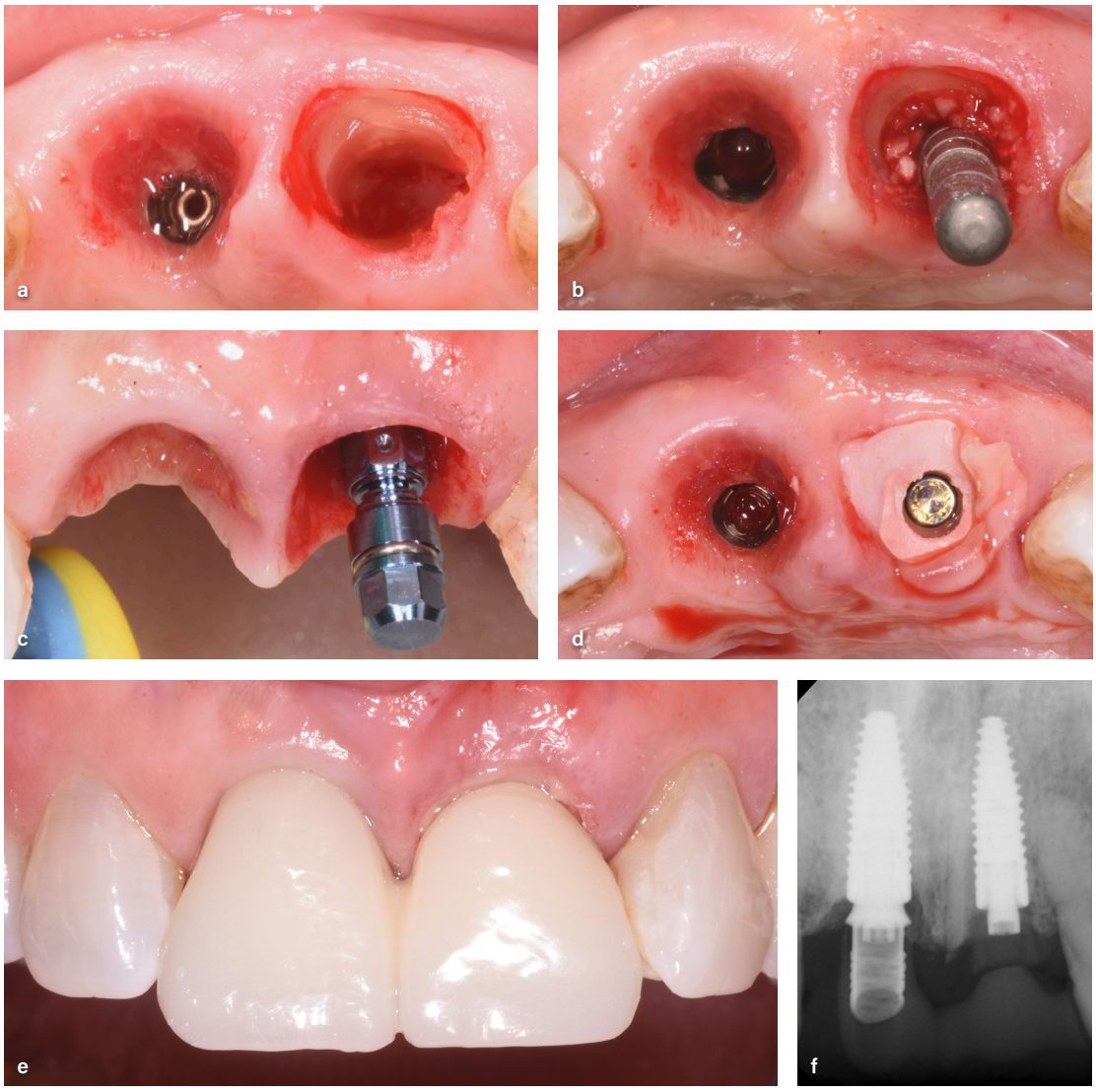
Facial bone wall*	> 1 mm thick	–	< 1 mm thick
Bone anatomy of alveolar crest	No bone deficiency	Horizontal bone deficiency	Vertical bone deficiency
Patient's esthetic expectations	Realistic expectations	–	Unrealistic expectations

Shaded cells indicate the patient's condition at the evaluation. Compared to the previous ERA, note the different scoring for width of edentulous span and the restorative status of neighboring teeth.
[Au: Please clarify what the asterisk and superscript numbers indicate.]

Surgery and Restoration of the Left Central Incisor

At the 5-year follow-up for site 11, the periapical radiograph showed bone stability, but a horizontal root fracture was also seen on the left central incisor (tooth 21; Fig 11). The patient confirmed she was aware of mobility of the tooth but did not have pain except when applying pressure and did not recall trauma. A CBCT scan confirmed a complete horizontal fracture of the tooth and suggested areas of ankylosis and palatal resorption. Tooth replacement was required.

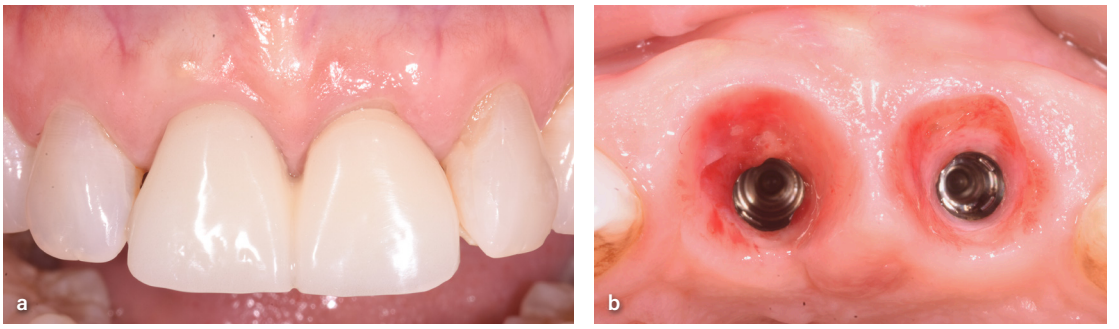
A new ERA was performed. Original concerns of maintaining excellent esthetics remained, but the risk was increased due to the impending loss of tooth 21 and difficulty in maintaining anterior interimplant papilla height (Table 2).[20] Different treatment options were considered, including a



▲ **Fig 12** *(a)* Occlusal view of the prepared root for the left central incisor and a sulcular view of the right implant. *(b)* The final guidepin was placed in the osteotomy, with the root prepared and the gap grafted. *(c)* Labial view of the implant placement. *(d)* A custom healing abutment was placed through a platelet-rich fibrin membrane to seal the socket. *(e)* A provisional restoration was cantilevered from the original implant at the completion of surgery. *(f)* An immediate postoperative radiograph shows a mesial root fragment at approximately the same vertical position as the mesial interproximal bone height of the right central incisor implant. A small gap is present between the implant and root.

cantilevered fixed prosthesis from tooth site 11 and immediate implant using a procedure, like what had been done on the other tooth 5 years prior. Ultimately, implant placement with PET (also known as *socket shield*) was chosen.

Before surgery, a screw-retained cantilevered provisional from site 11 was fabricated, covering site 21 so immediate load could be avoided. The patient presented for surgery and was premedicated with 2 g amoxicillin. The restoration at site 11 was removed and saved. Tooth 21 was decoronated, and a semilunar internal preparation was done to allow extraction of the apical and palatal portions of the root. The internal root surface was contoured and finished to a shell (1.5 mm thick) that was approximately level with the alveolar crest using a dedicated drill kit (PET kit, MegaGen). The root fragment extended from the distofacial to the mesiopalatal line angles (Fig 12a). An osteotomy was created against the palatal wall, leaving a



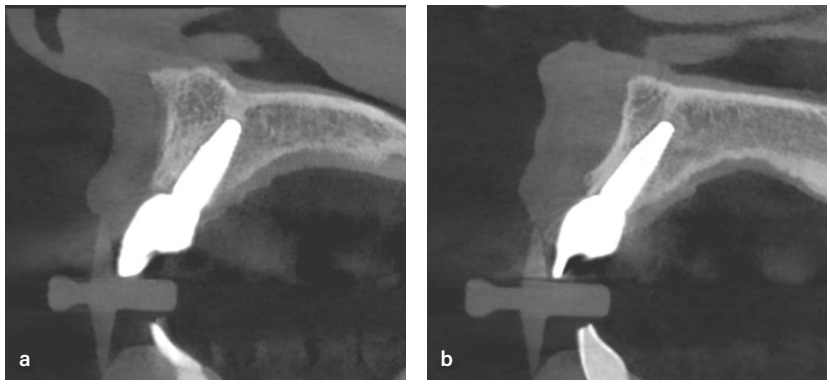
▲ **Fig 13** Clinical views at the 10-week follow-up. *(a)* The labial view shows labial and interproximal tissue stability. *(b)* The occlusal view after removing the provisional restoration shows a healthy gingival sulcus for both implants.

▲ **Fig 14** One year postoperative. *(a)* Clinical view with a new final restoration on the left central incisor and the original crown replaced on right central incisor. The interdental papilla is in exactly the same position as pretreatment photos, and labial gingival margin symmetry was maintained. *(b)* A radiograph shows the maintained crestal bone levels on both central incisors.

buccal gap (approximately 2 mm) that was filled with freeze-dried bone allograft hydrated with platelet-derived growth factor (Gem21S, Geistlich) (Fig 12b). An implant (3.3 x 12 mm; BLT NC, Straumann) was seated so that the platform was 1 mm apical to the coronal portion of the socket shield and 3 mm apical to the midfacial gingival margin (Fig 12c). A PEEK healing abutment was shaped to maintain gingival contours without contacting the root shell. A platelet-rich fibrin membrane was obtained and perforated by the healing abutment, then adapted over the socket to close the site (Fig 12d).[20] The cantilevered provisional restoration was then secured to tooth site 11 (Figs 12e and 12f).

After 4 months, the provisional restoration was removed to inspect the marginal mucosa, with findings suggesting good healing without loss of papilla height or volume. There was an area of exposed root surface (0.5 x 2 mm) in the sulcus of site 21, surrounded by noninflamed gingiva (Fig 13). This was managed by reducing the fragment with a fine diamond, and the contour of the healing abutment was reduced to create space for tissue proliferation over the fragment until there was no inflammation. The patient was then referred to her restorative dentist, who replaced the original crown on site 11 and had a new screw-retained crown fabricated on site 21.

One year after surgery, the patient returned for a final evaluation. The interimplant papilla maintained its original dimension, and the patient was satisfied with the esthetic outcome (Fig 14). A periapical radiograph confirmed that the interimplant bone peak, which was coronal to the



▲ **Fig 15** *(a and b)* CBCT images of site 11 and 21, respectively, showing optimal bone levels.

implant platforms, had been maintained. At 18 months postsurgery, a CBCT scan was taken. The interproximal root shield was interposed between the implant and bone peak (Fig 15). There was no suggestion of crestal bone remodeling, gingival inflammation, or recession. On both restorations, a pink esthetic score of 14 was obtained, which indicates excellent esthetic results.[2]

Discussion

This case illustrates the use of multiple techniques to optimize tooth replacement in the esthetic zone over a 6-year period. When tooth 11 was replaced, the patient had a single tooth span with intact periodontal attachment on adjacent teeth. This preserved the highly scalloped gingival architecture, as confirmed in numerous studies on single implants in the esthetic zone.[21,22]

Preserving buccal tissue volume, contours, and tissue stability were equally important in obtaining a successful result. Long-term documentation can be found in newer publications confirming hard and soft tissue stability specifically for immediately placed implants in the maxillary central incisor region, confirming the benefit of strategies outlined in the 10 Keys checklist.[12,23] It is important to focus on reports exclusively on central incisors, as patients and dentists place the greatest importance on esthetic outcomes at these locations, and the most common esthetic complications are associated with these sites.[23,24]

When the patient was seen with a fractured tooth 21, many treatment factors changed and were easily identified through the ERA criteria.[25] This time, the main clinical feature was that the edentulous gap changed from a single tooth to a two-tooth space, changing the local anatomical tissue dynamics. Losing tooth 21 was likely to have instigated loss of the adjacent intact periodontal attachment, which was maintaining the 7-mm papilla height between the central incisors. Reports suggested that a papilla height of 3 to 4 mm could be expected if the fractured tooth was replaced with an implant without additional protocols, and thus placing another implant with the 10 Keys checklist was rejected [Au: This should be mentioned in the section about replacing tooth 21.].[26] Extracting the tooth and replacing it with a cantilever was discussed to avoid the problem of interproximal bone and papilla loss in adjacent implants. In fact, Tymstra et al found that there were no differences between implant-implant and implant-cantilever papillae.[27] However, in the discussion of that study, the authors stated that papilla scores were "relatively low, pointing towards a compromised papilla presence in both groups; also, the inter-implant papillae scored worse compared with papillae between an implant and a natural tooth." In the present case, a compromised result would have not been acceptable at all. The clinicians aimed to maintain the same papilla height that can be found between two healthy, natural teeth. Given the unusual dental anatomy of the patient (exceptionally triangular teeth, unusually long papilla), the risk of a compromised papilla outcome was too concrete, and hence the cantilever option was discarded. Submerging the root of tooth 21 while using site 11 for

a cantilevered restoration was also considered. Root submergence has been shown to preserve interproximal bone and volume.[28] However, the resulting cantilevered prosthesis was projected to be biomechanically unfavorable due to potentially high shear forces in this young patient.

It was ultimately recommended to preserve the periodontium, exploiting the properties of periodontal attachment maintenance of root submergence with the biomechanical advantage of placing another implant using PET.[29–31] Because it was planned to use a smaller implant diameter (3.3 mm), high primary stability was not anticipated at the time of placement, preventing immediate loading.

The 1-year postoperative radiograph indicates 3 to 4 mm of bone remained coronal to the implant platforms after treatment. Clinical results show stability of the highly scalloped papillae, maintenance of gingival contours, and excellent esthetics.

Conclusions

This case report demonstrates short-term (site 21) to long-term (site 11) results for treatment of a patient who lost both central incisors over a 5-year period. The challenges of replacing these teeth differed significantly because of the specific features of each circumstance. Excellent results were obtained using different strategies to address the specific challenges of replacing teeth in a tooth-bound gap vs a tooth-implant bound gap. It is important for clinicians to carefully assess and diagnose conditions before making treatment recommendations and performing treatments in the esthetic zone. Clinicians need to have a biologically based comprehension of wound healing and multiple treatment modalities available to provide care.

Acknowledgments

The authors declare no conflicts of interest.

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